TP 6912E

DESIGN, DEVELOPMENT AND TESTING OF A MODIFIED FLYER BUS AS A RAILBUS

PREPARED FOR THE
TRANSPORTATION DEVELOPMENT CENTRE
TRANSPORT CANADA

BY

I. A. LUCKHURST AND DAVID GARDINER
WINNIPEG COACH SALES AND SERVICE LTD.

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AUGUST, 1985

BY
H. A. LUCKHURST AND DAVID GARDINER
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17. Abstract

This report documents the testing of a Flyer bus modified by Winnipeg Coach Sales & Service for operation on railway lines. The modifications entailed installing railway wheels, stabilizing the front axle and strengthening the front suspension to minimize sway.

Initial operating tests took place July 11th and 12th, 1984, on the Greater Winnipeg Water District (GWWD) railway line. Push, pull and powered tests were conducted, including braking and operation on curves of up to 16 degrees and through crossings at varying speeds. The bus was also operated for a distance of 31 miles (50 km) on the GWWD tracks at speeds of up to 40 mph (64 km/h). The bus performed all tests satisfactorily and the test program was judged successful.

Prior to the Phase II test in February, 1985, a turntable was installed to permit the bus to be turned around where no Y trackage or other means of turning are available. However, it was not ready for testing until the Phase III series in April, 1985.

Equipment added prior to Phase II included a snow plow, power winch, auxiliary heater and double-glazed windows. The undercarriage was modified to improve ride quality. The railbus was operated a distance of 194 miles (310 km) on the GWWD line.

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17. Résumé

Ce rapport rend compte des essais d'un autocar Flyer adapté par la compagnie Winnipeg Coach Sales & Service à la circulation sur rails. Les modifications ont consisté en la pose de roues métalliques à boudin, la stabilisation du train avant et le renforcement de la suspension avant pour réduire les mouvements de roulis.

Les premiers essais ont eu lieu les 11 et 12 juillet 1984 sur le réseau ferroviaire du Greater Winnipeg Water District (GWWD). Ils ont comporté des essais de poussage, de traction et de marche autonome, y compris des essais de freinage et aussi de franchissement d'appareils de voie et de courbes de 16° maximum, à différentes vitesses. Au cours de ces essais, le véhicule a parcouru 31 milles (50 km) sur le réseau précité, à une vitesse maximum de 40 mi/h (64 km/h). Le railbus s'est bien comporté dans toutes les phases du programme d'essais, lequel a été déclaré une réussite.

Avant la phase II des essais, réalisés en février 1985, une table tournante a été aménagée pour permettre au véhicule de faire demi-tour en l'absence de branchement, croisement ou autre appareil de voie. Malheureusement, cette table tournante n'a pu servir avant la phase III du programme d'essais, soit en avril 1985.

Toujours avant la phase II, le véhicule a été équipé d'une lame chasse-neige, d'un treuil mécanique, d'une installation de chauffage auxiliaire et de vitrages doubles. Le châssis a également été modifié pour améliorer la stabilité de marche. Au total, le véhicule parcouru 194 milles (310 km) sur les voies du réseau GWWD.

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SECTION I

PHASE I-A and I-B TEST PROGRAMS

1.0 INTRODUCTION

1.1 Background

Winnipeg Coach Sales & Service has been in the process of designing and developing a prototype railbus utilizing a converted Western Flyer highway bus.

This project began as a result of the Canadian Transport Commission hearings in Northern Manitoba in May and June, 1981, in response to VIA Rail's application to discontinue northern rail passenger services.

The issue of railbus technology was put forward at these hearings as offering opportunity of serving remote communities located along existing rail lines.

In its submission in support of continued rail passenger service in northern Manitoba, the Manitoba Government stated, "the Manitoba Government recommends that the trains under consideration be maintained. This does not necessarily mean that rail services have to remain precisely as they are today. The Rail Transport Committee and VIA Rail should look at alternative means of providing as good, if not better service."

Subsequent to the hearings the Rail Transport Committee ordered VIA "... to evaluate new forms of low density rail passenger services ...".

VIA's evaluation was found unacceptable by northerners (The Northern Transportation Committee) and by the Manitoba Government. At a subsequent Railbus Committee meeting in Winnipeg (May 21, 1982), the representative of the CTC supported the railbus concept as did the Northern Transportation Committee (NTC) and the Manitoba Government.

1.2 Railbus Feasibility - A Preliminary Evaluation of a Proposed Railbus Demonstration Project

In order to initiate the project a study was commissioned by the Manitoba Department of Highways and Transportation. It was conducted by M. J. Babulic, Superintendent of Transportation at Inco in Thompson. The study confirmed the need for service in the north and recommended a demonstration project be set up between Thicket Portage, Thompson and Pikwitonei. A converted highway bus was identified as the preferred vehicle for this test.

At a meeting of interested parties called in April, 1983, in Thompson, the report was reviewed and accepted and a working group (Railbus Working Group) set up, chaired by Commissioner Wolfe of the Canadian Transport Commission. Membership on this committee reflected the widespread interest in this project. Represented were:

- The Canadian Transport Commission
- Transport Canada - Rail Passenger Division
- Transport Canada - The Transportation Development Centre
- The Governments of Manitoba, Alberta and Ontario
- VIA Rail
- CNR
- Northern Manitoba Groups - Norman Development Corporation
  - Northern Transportation Committee

The purpose of the railbus demonstration project was to develop a better, cost-effective method of providing passenger services to light density, remote areas on existing rail lines.

Bids were invited from bus manufacturers and delivery times requested. Based on timing and cost savings the Flyer inter-urban bus, converted to operate on rails, was chosen as the test vehicle.

The demonstration process was then costed. The program was subsequently included in the Canada-Manitoba Transportation Sub-Agreement.

A decision was made by the group to request the Transportation Development Centre (TDC) to handle the testing process and, pending completion of arrangements for the purchase, to finance the conversion of the bus and its initial testing program.

A contract was signed between Winnipeg Coach and TDC in April, 1984, and conversion of the bus commenced.

1.3 Modifications to Bus

A basic Flyer bus circa 1961 was acquired and gutted - seats and interior fixtures, the engine, axles and undercarriage were removed.

The engine was replaced with a 453 Detroit Diesel coupled to 540 Allison Automatic Transmission. The undercarriage was modified by suspending Rockwell front and rear axle assemblies from the regular channel iron frame. New seats and luggage racks and a rear toilet were installed and the heating equipment reconditioned, and new floor covering was added. Windows were double glazed, auxiliary heaters installed, a snow plow was installed and wheel wells reinforced to facilitate jacking up the vehicle.

Delco telescopic type shocks (dampers) were mounted on the undercarriage front and back.

Front suspension was adapted for rail application using a rear end axle assembly reworked for front end suspension use.

The regular bus wheels were retained on the bus. Rail wheels were adapted so they could be readily attached to the bus hubs.

1.4 Description of Test Programs

1.4.1 Background

The tests that were undertaken included centre of gravity and suspension tests carried out by the Prairie Agricultural Machinery Institute (P.A.M.I.) which had the necessary equipment; unpowered and powered running tests, braking tests, speed and endurance tests and turntable tests.

The P.A.M.I. tests are described as Phase I-A and the subsequent operating tests as Phase I-B. The Phase I tests were conducted at the Winnipeg Coach plant in June, 1984, while the Phase I-B tests occurred in July at the Greater Winnipeg Water District Railway yards, 498 Plinquet Avenue, Winnipeg, and on the Railway's Shoal Lake line to Mile 31.

1.4.2 Test Timing

The first tests took place over a two day period - July 11th and 12th, 1984. The tests involved testing the bus with and without power. The Greater Winnipeg Water District Railway provided trackage, a powered rail car for towing and 2 operators.

The second (Phase II) test was to check the turntable and endurance of the railbus by running to Shoal Lake, a total distance of 194 miles (310 km). The third test (Phase III) was needed as the turntable was not completed in February. Further ride quality testing was also done after re-profiling the wheels and changing the undercarriage.

1.4.3 Test Purpose

The purpose of the series of tests was to provide a broad appreciation of the operating characteristics of the railbus test vehicle on rails by subjectively observing the reaction of the bus and particularly the undercarriage and the wheel-rail contact results. Reactions were sought at varying speeds, forward and reverse, powered and unpowered, on various tangent and curved trackage.

2.0 TESTING PROGRAM

2.1 Phase I-A - Centre of Gravity and Suspension Tests

These tests were carried out by the Prairie Agricultural Machinery Institute.

2.1.1 Objective

The object of this work was to determine the centre of gravity and suspension stiffness of a highway bus equipped for operation on the rail line. The major purpose of these tests was to ensure safety of the bus during this new form of operation.

2.1.2 Scope

The centre of gravity of the highway bus, with seats, without passengers and with the fuel tank empty, was determined using 12,000 pound load cells and taking the weight measurements at each of the wheels with the bus in a horizontal position for the longitudinal and lateral directions. The vertical centre of gravity was determined by hoisting the front of the bus and recording the weight at the pivoting wheels and the height lifted (Figure 1). Load cells were calibrated before and after the test.

The stiffness of the front and rear suspension was determined by recording the weight and the spring deflection at each wheel as the frame was gradually lifted and lowered.

The results of the test are given under their appropriate headings.

2.1.3 Centre of Gravity

Several attemps were made to determine the vertical centre of gravity by hoisting the rear of the bus while recording the transfer of weight onto the front wheels; however, recorded weights were conflicting. It was decided to attempt to determine the centre of gravity by hoisting the bus from the front.

The following is the tabulation of the readings recorded on the load cells along with the centre of gravity determinations.

Table 1: Weight and Centre of Gravity Test Results

Weight:	Left	Right	Total
- front wheels	1646 kg	1556 kg	3202 kg
- rear wheels	2004 kg	2072 kg	4076 kg
Total:	3650 kg	3628 kg	7278 kg
Wheelbase:	6200 mm (244 in)		
Centre of Gravity:			
- longitudinal (rearward from front axle centre)	3480 mm (137 in)		
- lateral (to left of centre line)	2 mm (.09 in)		
- vertical (angle of tilt = 13°) (upward from axle centre)	150 mm ± 25 mm (6 in ± 1 in)		

2.1.4 Suspension Stiffness

The load-deflection curves for the suspension of each wheel of the bus frame are given in Figures 2 and 3, while the average stiffness of each wheel is tabulated below.

Table 2: Suspension Stiffness Test Results

Left Rear:	23 to 24 kg/mm	(1290 to 1340 lb/in)
Right Rear:	25 to 32 kg/mm	(1400 to 1790 lb/in)
Left Front:	22 to 26 kg/mm	(1230 to 1450 lb/in)
Right Front:	19 to 22 kg/mm	(1060 to 1230 lb/in)

FIGURE 1

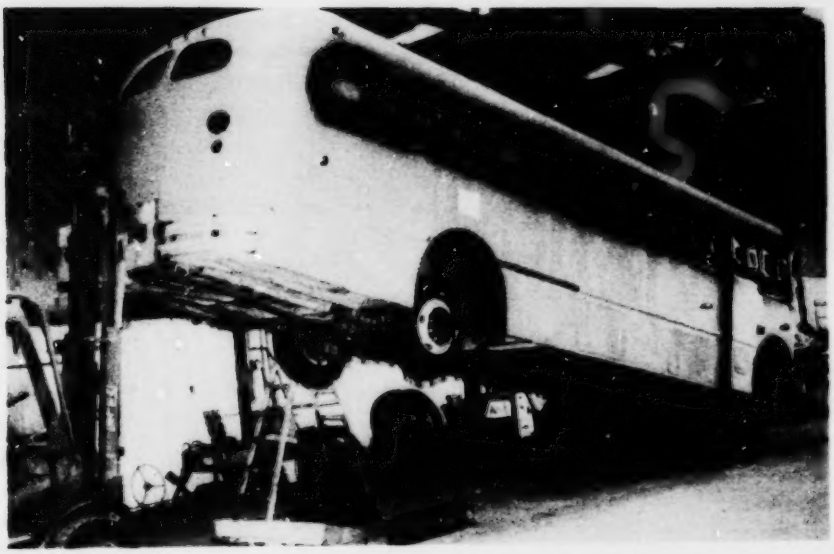


Photo. 1 - Centre of gravity determination, vertical.

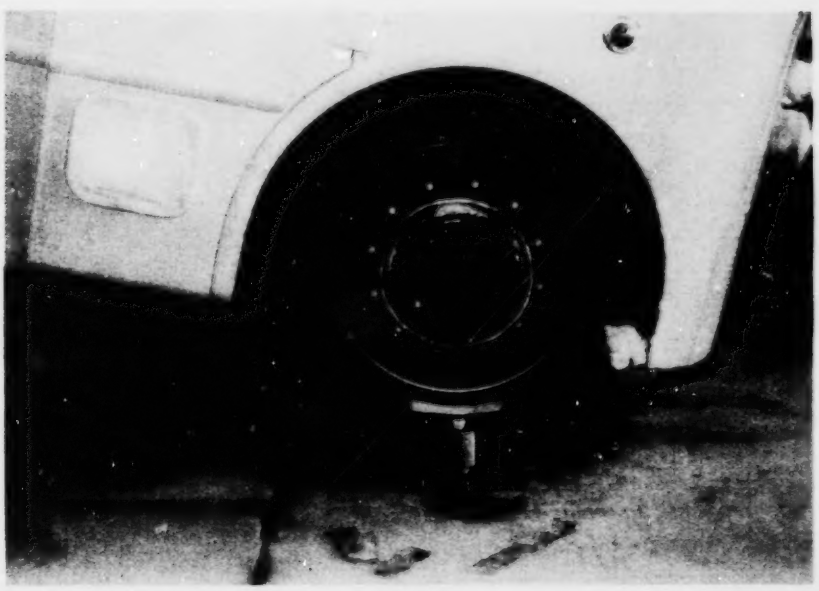


Photo. 2 - Method of wheel weight measurement.

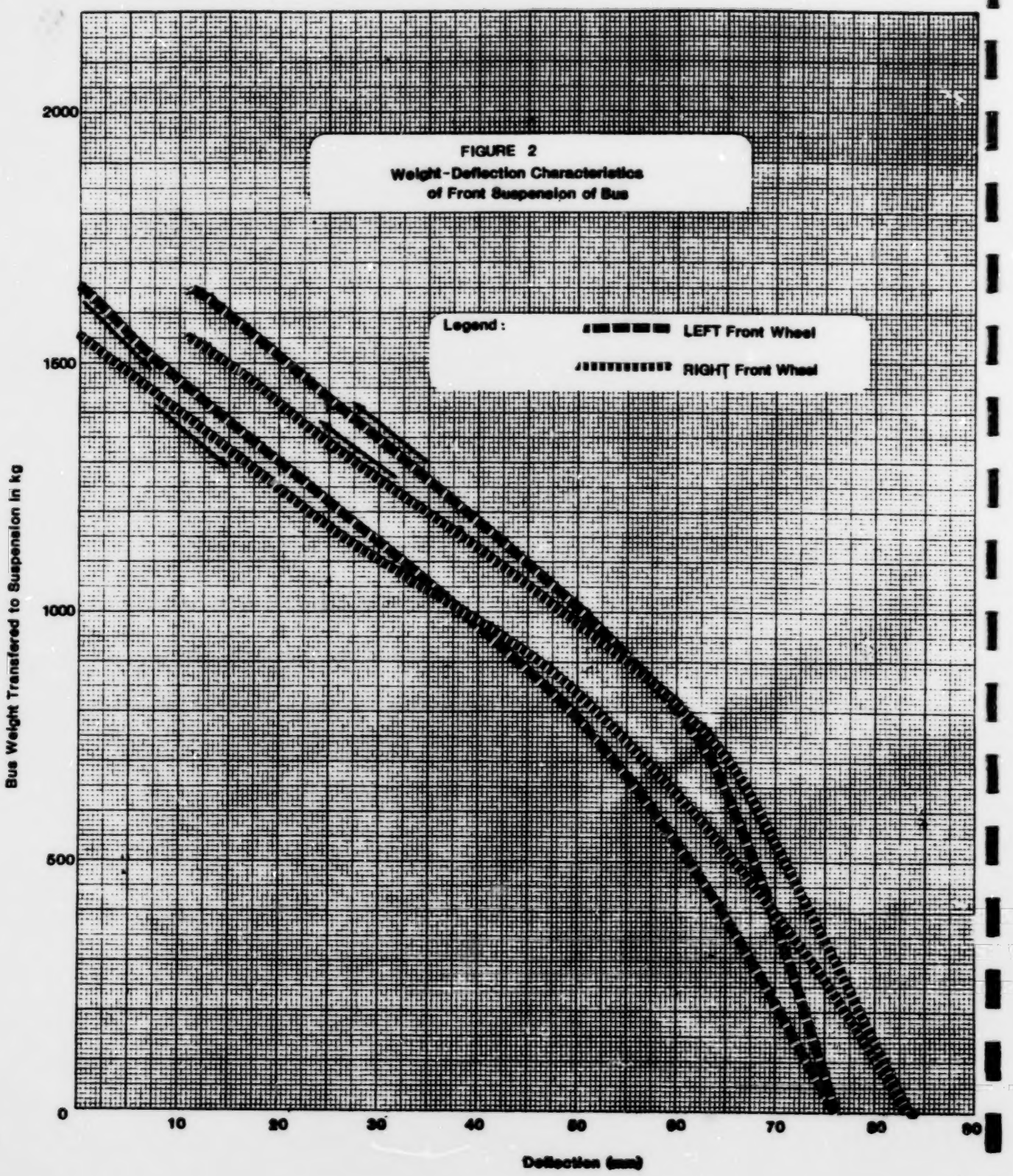


FIGURE 2
Weight-Deflection Characteristics
of Front Suspension of Bus
Legend :
LEFT Front Wheel
RIGHT Front Wheel
Bus Weight Transfered to Suspension in kg
2000
1500
1000
500
0
10
20
30
40
50
60
70
80
90
Deflection (mm)

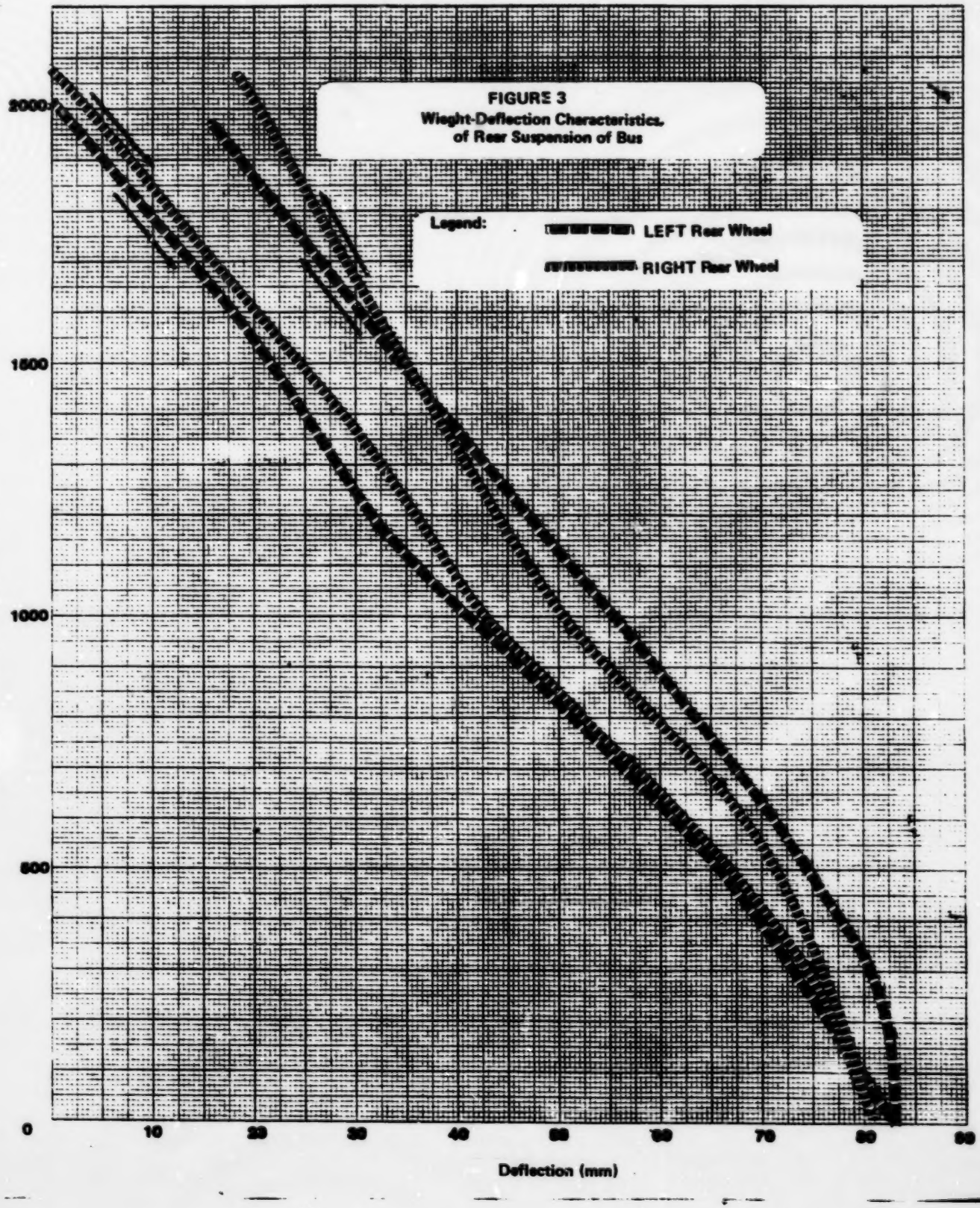


FIGURE 3
Wieght-Deflection Characteristics
of Rear Suspension of Bus
Legend:
LEFT Rear Wheel
RIGHT Rear Wheel
Bus weight Transfered to Suspension in kg
2000
1500
1000
500
0
10
20
30
40
50
60
70
80
90
Deflection (mm)

2.2 Phase I-B Field Tests

This phase took place at Winnipeg Coach Sales & Service plant (on-board inspection) and at the Greater Winnipeg Water District. The Push/Pull tests were carried out July 11 and the powered tests July 12. A chart of the GWWD yards and line to Indian Bay (Shoal Lake) is provided in Appendix A-3.

2.2.1 Test Objectives

1. Check on-board systems operation.
2. Establish unpowered/powered vehicle handling.
3. Measure brake and acceleration performance.
4. Establish ability to negotiate switches.
5. Establish speed capability.
6. Verify performance and integrity of suspension.
7. Identify problem areas for redesign.

2.2.2 Test Program

a) On-Board Inspection

The equipment required for the operation of the railbus and for conducting the running tests was inspected and except for the engine cover was found to be satisfactory and operational.

b) Push/Pull

The railbus was pushed and pulled at various speeds up to 25 mph, 40 km/h by a host vehicle using a loose drawbar arrangement to ensure no vibrations or rocking actions was transmitted from the host vehicle to the railbus. Tests were made on tangent and curved track up to 16°. Several runs were made at each speed starting at 5 mph, 8 km/h. The host vehicle speedometer was read during each run.

Tests were run as follows with each duplicated at least once.

1. Push and pull on tangent track to 5 mph, 8 km/h.
2. Plush and pull on tangent track to 10 mph, 16 km/h.
3. Push and pull on curved track to 5 mph, 8 km/h.
4. Push and pull on same curved track in opposite direction.
5. Push and pull on tangent track to 15 mph, 24 km/h.
6. Push and pull on tangent track to 20 mph, 32 km/h.
7. Push and pull on tangent track to 25 mph, 40 km/h.
8. Repeated 3 on curved track to 10 mph, 16 km/h.
9. Repeated 4 on curved track to 10 mph, 16 km/h.

c) Powered Tests

The railbus was run under its own power in the yard and then taken out to mile 31 and back. The yard tests included speed, curves, push/pull of a 50 ton vehicle, emergency brake, braking and runs on a poorly maintained siding. The road test consisted of a run out to mile 31 at various speeds, and a number of braking and acceleration tests. The operator was allowed to use his discretion as to maximum speed to attain. During the run single and 3 diamond crossings were negotiated.

The tests run with the railbus under its own power (each test was duplicated at least once) were as follows:

1. Acceleration and braking on tangent track to 5 mph, 8 km/h.
2. Repeat at 10 mph, 16 km/h.
3. Maximum acceleration test to 10 mph, 16 km/h.
4. Reverse runs at approx. 2½-3 mph, 4-5 km/h.
5. Repeat 1 at 15 mph, 24 km/h.
6. Repeat 5 and stop using emergency brake in distance of about 50 yards, 46 meters.
7. Repeat 5 and stop using up to 30 psi on brake.
8. Repeat 7 at 20 mph, 32 km/h.
9. Repeat 8 with 55 psi brake pressure.
10. Adjust braking air distribution between front and rear brakes and repeat 9.
11. Run through 11° rt. hand curves at 5 mph, 8 km/h and reverse through curve.
12. Run through 13° left hand curve at 5 mph, 8 km/h and reverse through curve.
13. Move to poorly maintained track siding and operate at 5, 10 and 15 mph, 8, 16 and 24 km/h. (The track was not long enough to accelerate to a higher speed.)
14. Connected bus by drawbar to a 50 ton vehicle and carried out push/pull tests up to 10 mph, 16 km/h under railbus power.
15. Operator of load vehicle applied brakes and noted the pressure at which railbus was labouring (25 psi).
16. Operator of load vehicle applied full brake.
17. Took vehicle on 31 mile, 50 km run at speeds up to 40 mph, 64 km/h. (Speeds were left to discretion of experienced driver who chose 40 mph, 64 km/h as his maximum.)
18. Ran through inside and outside curves at speeds of 20 mph, 32 km/h (11° + 13°).
19. Checked time and found stopping distance at 40 mph, 64 km/h was 200 feet, 61 metres.
20. Determine weight was adequate to set off a "Torpedo".

3.0 GENERAL TEST OBSERVATIONS

- General

Again there were no mechanical failures. Bearings did not get hot and tracking on tangent and curved track was excellent. The tests were therefore judged to be successful.

- Sound Levels

The engine air compressor was too large for the existing compartment, hence the cover could not be closed resulting in excessive interior noise. No meters were available to measure the sound level. Other noise did not seem excessive.

- Braking

Both emergency and regular braking were excellent except for some locking of the rear brakes before pressure distribution adjustments were made. The railbus could be stopped from 30 mph, 48 km/h in 10 seconds over a distance of 180 feet, 55 meters. From 35 mph, 56 km/h, 13 seconds were required (the distance was not measured). At 40 mph, 64 km/h, 16 seconds were required. The distance was approximately 200 feet, 61 meters.

- Power

The bus was able to push a 50 ton (approx.) vehicle with up to 25 psi brake pressure applied without losing traction.

- Vibration

There was little vibration transmitted to the body. When the camera was mounted on the frame, it gave as clear a picture as when mounted on the axle. The stiffness of the suspension also undoubtedly reduced vibration.

- Speeds

The operator chose not to exceed 40 mph, 64 km/h because it was the first time he had operated the vehicle and he did not have as good a feel for the track as he would normally have in other vehicles he operates on these tracks.

- Weight

The bus was also heavy enough to trigger a "Torpedo" warning device placed on the tracks.

Table 3: Speedometer Correction for 36" Rail Wheel (Circumf. = 114")

Indicated Speed		Actual Speed	
mph	km/h	mph	km/h
0	0	0	0
5.0	8.1	4.3	6.9
5.8	9.3	5.0	8.0
10.0	16.1	8.6	13.8
11.6	18.6	10.0	16.1
15.0	24.1	13.0	20.9
17.4	28.0	15.0	24.1
20.0	32.2	17.3	27.8
23.2	37.3	20.0	32.2
25.0	40.2	21.6	34.7
28.9	46.5	25.0	40.2
30.0	48.2	25.9	41.6
34.7	55.8	30.0	48.2
35.0	56.3	30.2	48.6
40.0	64.4	34.5	55.5
40.5	65.2	35.0	56.3
45.0	72.4	38.9	62.6
46.3	74.5	40.0	65.2
52.1	83.8	45.0	72.4

NOTE: All references in the report mean "Indicated Speed" not actual speed except during Push/Pull tests (July 11/84) when the host vehicle speedometer was read.

- Railbus Wheel Profile

Front

Left	dia. = 36½" on centre line
Right	dia. = 36 5/16" on centre line

Rear

Left	dia. = 35 3/4" on centre line
Right	dia. = 35 3/4" on centre line

Wheel Gauge of flanges back to back

Front	53 3/16"	Front
	53 5/16"	Rear
	1/8"	Toe-in
Rear	53 5/16"	Front
	53 1/4"	Rear
	1/16"	Toe-out

4.0 CONCLUSIONS

The major purpose of these tests was to determine the feasibility of travel on rails using a combination of bus and railway components.

There is no doubt that a positive conclusion can be reached since mechanically and dynamically the vehicle performed up to expectations. Braking and acceleration were acceptable although some wheel locking occurred. Pressure adjustments were able to correct this problem except when coming to a stop. Driver experience will correct this problem. During the tests the bus was not pushed to excessive speeds.

The engine noise factor can be discounted since a proper engine cover and insulation can be devised to reduce this aspect to an acceptable level.

It is probable that a smaller engine could be used since the bus should not be expected to push a 50 ton load even where snow is being plowed.

Our information is that the track in the Thompson area is designated as 30 mph, 48 km/h maximum and the railbus has exceeded that limitation.

4.1 Follow Up Check

Following completion of the tests the bus was returned to the shop for examination. The wheels were removed and the wheel bearings examined for wear. No wear is indicated and all hubs are in excellent shape. The bearings were then re-packed with grease as opposed to the former oil bath.

4.2 Work To Be Completed

The following was to be completed before the railbus could be sent to Thompson for further trials:

1. Provide proper engine cover to deaden noise.
2. Complete gear shift mechanism changes.
3. Provide interior heating.
4. Install and test a turn-around mechanism that can be handled by one person.
5. Provide emergency radio communication service to a central office.
6. Complete interior finishing and install washroom facilities.

SECTION II

PHASE II TEST PROGRAM

1.0 INTRODUCTION

1.1 Background

This section of the report describes the second and third test series which took place in Winnipeg and via Greater Winnipeg Water District (GWWD) Rail line to Shoal Lake, 97 miles, 155 km east of Winnipeg.

The test programs included inspection of the bus to ensure additions and modifications to the vehicle were completed in accordance with the amended contract.

1.2 Location and Date

As for Phase I testing, these tests were also held at the Greater Winnipeg Water District rail yards and line to Shoal Lake, a distance of 194 miles, 310 km return. The tests were conducted on February 14th and 15th, 1985.

1.3 Specification Changes

Some of the original specifications were changed prior to the Phase II tests. These changes are detailed in Appendix E.

2.0 TEST REQUIREMENTS - PHASE II

The following is a description of the tests which were scheduled:

2.1 Stationary - Pre Tests

The following were checked:

- wheel bolts
- brake pressure
- lift mechanism
- horn
- emergency brake
- undercarriage and chassis (checked for leaks)
- snow plow clearance

2.2 Stationary - Operating

- brakes - creeping with foot and hand brake applied
- heaters - temperature difference (interior to exterior)

2.3 Moving

- Traverse 11°-13° curved track at 10 mph
- Wheel bolts checked

2.4 Braking

Braking tests were conducted at speeds of 10, 20, 30 and 40 mph, 16, 32, 48 and 64 km/h using:

1) foot brake
2) emergency brake

The vehicle was checked for drive wheel slide to test stopping capability.

2.5 Turntable

The lift mechanism was to be used to raise the vehicle from the tracks so it could be turned 180° and then lowered back onto the rails. Lift and turn stability at 90° position to be checked.

2.6 Moving - Other

Following travel tests, heat build-up was checked in the following:

- wheel bearings
- engine
- oil and air pressure was checked
- lift mechanism locking device was checked

2.7 Endurance Test

The vehicle was driven with a passenger load to the end of trackage and return, a distance of 194 miles, 310 km.

3.0 TEST PROGRAM

The tests described in 2.3 took place at the Greater Winnipeg Water District yards February 14th and on the Greater Winnipeg Water District rail line February 15th, 1985.

3.1 Stationary Mechanical Pre-Tests

The mechanical condition of the bus was checked given the fact it had not been in service since July, 1984. This covered the following:

- wheel bolts - tight
- brake pressure - 60 psi and constant
- lift mechanism - secured in raised position
- horn - tested and found operational
- emergency brake - mechanism operational
- undercarriage inspection - the bus was positioned over the GWWD pit and the undercarriage inspected for leaks, weld breaks, etc. None were found.
- snow plow - this equipment was installed after the first test. It was checked for road bed clearance and was raised prior to running tests to 3" clearance.

3.2 Other Stationary Tests

- Bus creeping with brakes applied.

  The bus was put in gear and the engine revved up to about 2000 rpm. The foot brake was first applied then the emergency. Both were found to hold and creeping was negligible.

- Heaters - the interior heaters were tested and found to maintain interior heat at the comfort range 15-20° C when exterior temperature was in the -15° C range.

3.3 Moving Tests

The vehicle was operated through a 11°-13° curved track at a speed of 10 mph, 16 km/h and was found to perform in a similar manner to that which occurred during the July, 1984 test in that it navigated the curves without difficulty.

Wheel bolts were checked and found tight.

3.4 Braking

The braking tests conducted in 1984 were repeated.

Brakes were applied at 10, 20, 30 and 40 mph, 16, 32, 48 and 64 km/h. Stopping distances were not measured but results were judged satisfactory.

3.5 Miscellaneous Moving Tests

During the operation of the railbus to Shoal Lake, periodic checks were made to check heat build up in the interior, wheel bearings and engine with the following results:

- Interior - Temperature was measured periodically using a digital read-out thermometer. There was heat build up from 23° C to 29° C as the trip progressed.
- Wheel bearings were found to remain at a satisfactory temperature except for slight overheating in left front.
- Engine - operated at 210° F or 98° C.
- Oil and air pressure were also checked and found to be constant.

3.6 Distance Trip (194 miles - 310 km)

The bus was inspected on arrival at Shoal Lake and all mechanical components were found to be in good condition. The test run was then completed by returning to Winnipeg.

Elapsed time was:

Winnipeg - Shoal Lake - 3.22 hours
Shoal Lake - Winnipeg - 3.06 hours

The bus was operated at indicated speeds of 50 mph, 80.5 km/h outbound and 45 mph, 72.4 km/h inbound for short periods of time on straightaway track. (Actual speeds were 45 mph, 72.4 km/h and 40.5 mph, 64.8 km/h.)

The vehicle activates signal lights at highway crossings. However, it was noted there was instability of rail signal lights in two instances when the vehicle crossed the activating mechanism on approaching the GWWD Railway yards. Lights turned from green to yellow and back to green.

3.7 Turntable Tests

The turntable was not operational at the time of the tests due to delay in obtaining parts and the necessity for some redesign of the hydraulic cylinders.

However, the operating procedure was worked out. The turntable was welded securely to the bus frame in the UP position and was checked to ensure the railbus could be safely operated with the turntable installed.

3.8 Winch

A winch was installed, and procedures for its operation were developed. The winch was tested in the shop and found to operate satisfactorily.

3.9 General Comments

- Ride Quality

  The ride quality was found to be comparable to the previous test but generally unsatisfactory. As a result it was decided to re-profile the wheels prior to delivery.

  A second set of matching wheels was also ordered.

4.0 TEST OBSERVATIONS

4.1 Turntable

The principal purpose of the second test program was initially to test and evaluate the turntable. This testing was not possible due to the need for modification and some redesign of the hydraulics. Turntable tests were therefore postponed to April, 1985.

4.2 Braking

Some further braking tests were conducted during the Shoal Lake run but as it was difficult to effect measurements, precise results could not be obtained. However, the holding capability of both foot and hand brakes was found to be satisfactory.

4.3 Ride Quality

Although sound level was reduced compared to Phase I tests, the general ride quality was found in need of improvement. A major contributor to the problem appeared to be the wheels which may have been flattened due to excessive braking pressure in the 1984 tests.

4.4 Further Work

It was therefore decided reprofiling of the wheels was needed and ride quality rechecked when the turntable was to be tested. It was also decided some additional work to the undercarriage was needed. Some further equipment was also found necessary.

This work was to be done and equipment supplied prior to a final Phase III test series.

Details of the work required and added equipment are described in Section III, the Phase III test program.

5.0 CONCLUSIONS

The purpose of the second test series (Phase II) was to test the turntable, installed after the first test, and to check modifications to the bus introduced as a result of the first test program. Additional equipment was specified after the first test and it was inspected to ensure it was in place and as specified. Phase II tests also included a final inspection of the vehicle to ensure it complied with original specifications. A distance run to the end of the Greater Winnipeg Water District line (194 miles, 310 km) and some additional braking tests were added to the Phase II test program.

The tests were all carried out successfully except for the turntable which was not operational at test time as some last minute modifications were needed. The snow plow was found to be too low and required raising to ensure clearance.

Following the Phase II tests some further modifications were specified, aimed particularly at improving the ride. The rail wheels were to be re-profiled, the shocks replaced and the springs re-arched. Some additional equipment was specified (second contract amendment) and some spares, including a set of wheels and safety equipment, were ordered. A third test series was ordered in order that the turntable could be tested operationally and the vehicle given a final test to check ride quality and inspected to ensure all equipment was supplied and modifications made.

SECTION III

PHASE III TEST PROGRAM

1.0 INTRODUCTION

1.1 Background

This section of the report details the inspection of modifications, revisions, and equipment additions decided upon following the Phase II test program. It also covers the testing of the operation of the turntable mechanism originally planned for the Phase II program. Some further running testing for ride quality and sound levels was also carried out and the results are described.

1.2 Location and Date

The inspection and testing of new equipment took place April 16th at the GWWD yards and the test run, primarily to test riding qualities, took place April 17th on the GWWD line as far east as mile 31.

1.3 Equipment

Some new equipment was added. It is listed in Appendix E.

1.4 Modifications

The principal modification was the remachining of the wheels to remove flat spots.

Other changes entailed adjustment to the snow plow and modifying the undercarriage to improve the ride characteristics.

2.0 TEST REQUIREMENTS

2.1 Inspection

There were no other pre-set test requirements other than to run through the check list of added equipment, examine the modifications that had been made to the bus and test ride the bus to assess the ride quality and characteristics including noise levels.

2.2 Turntable

The turntable was fully operational for the April 16th-17th tests and was tested using the procedure set out in Appendix H. This included lift and turn stability and stability at 90° positioning to tangent track.

Lift was to be locked into place and checked to ensure it would remain retracted in the event of hydraulic system failure or deactivation.

3.0 TEST PROGRAM

3.1 Introduction

In order to conduct the tests as outlined, the railbus was transported to the Greater Winnipeg Water District rail yard from the Winnipeg Coach plant.

3.2 Inspection

On day 1, April 16th, the railbus was first given a thorough inspection as to the modifications which had been made since the February tests and as to the new equipment installation. Wheels had been given identified markings, welds and bearings were inspected, wheel alignment and gauges were checked and fuel consumption calculated.

3.3 Turntable

The turntable was then tested. It was fully operational and was operated in accordance with the procedures established by the designers and builders of the lift - Messrs. Ochitwa and Gardiner.

The railbus was lifted from the tracks hydraulically then turned completely around and lowered back onto the track facing the other way.

Stability of the bus at 90° positioning to the track was checked. Lift and turn action stability and smoothness was also checked.

A mechanical lock mechanism had been installed to ensure the turntable reamined in the raised position when not in use. This mechanism involved automatic insertion of pins on the hydraulic guide mechanism. The pins are removed by activating the hydraulic power take-off.

3.4 Ride

The bus was operated to mile 31 and the ride quality was assessed in terms of smoothness and noise level.

The clearance of the snow plow was also checked after its repositioning following the Phase II tests.

The railbus was operated at various speeds and vibration and sound levels checked.

4.0 GENERAL TEST OBSERVATIONS

4.1 Introduction

The purpose of these tests was to ensure the bus had been completed in accordance with revised specifications, to ensure all specified equipment had been installed and to assess ride quality after the wheels were re-profiled. Sound levels were also considered further.

4.2 Inspection

The inspection was completed and changes and additions were found to be acceptable.

4.3 Turntable

The turntable operated smoothly with a minimum of sway while being lifted and the railbus rotated, even at the 90° position. The operating procedures were found to be satisfactory and easy to follow.

The locking mechanism also functioned well, locking the lift in the "UP" position and releasing when the power take-off was activated.

4.4 Ride

The railbus run to mile 31 revealed an improved ride due to smoother wheels and improved suspension. The noise level was also lower. This was achieved by a better fitting engine cover. It was felt, however, the noise level is in need of much improvement.

4.5 Follow-up Inspection

As specified, the wheels were given identifying marking and no misalignment was found. No cracks were found in any welds and bearings were in good condition. Exact fuel consumption was computed at 25 miles per gallon, 9 km per litre.

5.0 CONCLUSIONS

The railbus testing in Winnipeg was considered completed in a generally satisfactory manner and with expected results.

More work is needed to assess the stability of the railbus. The vehicle was to be relocated to Thompson, Manitoba, for further testing and evaluation.

APPENDIX A

THE TEST PROGRAM - PHASE 1-B

A) SAFETY CHECKING

N.B. Install shock-resistant platforms for video and lighting to record one front and one rear wheel movement perpendicular to rail plus placard holder for test numbers or a digital clock.

1. Measure suspension stiffness front and rear by means of hydraulic jacks and deflection measurement.

a)	Lateral	at zero	½ and full load
b)	Vertical	at zero	½ and full load
c)	Longitudinal	at zero	½ and full Resistance Load (i.e. u X weight)

Test 5 points increasing load and 5 points decreasing load.

2. Establish longitudinal and lateral CG position, unloaded. Lift at four locations (new jack points).

3. Establish vertical CG position by tilt (on rails, in shop or crane lift)

4. Tow and push vehicle with a resilient coupling to ensure ability to maneuver unpowered vehicle without damage

   a) at 5 mph, 8 km/h
   b) at 10 mph, 16 km/h
   c) at 15 mph, 24 km/h

   On tanget track and on a curve and through switches.

5. A) Acceleration and brake test vehicle for a non slip start and stop on dry and wet (oiled) rail

      a) to/from 5 mph, 8 km/h
      b) to/from 10 mph, 16 km/h
      c) to/from 15 mph, 24 km/h

   B) Establish distance using emergency mechanical brake on test section in each direction.

6. Traction tests at zero speed

   Measure drawbar pull up to wheel slip at zero load in various gears. Establish best starting gear.

7. Run vehicle on tangent track under power

   a) at 5 mph, 8 km/h
   b) at 10 mph, 16 km/h
   c) at 15 mph, 24 km/h

   Measure track deviations that cause severe motions.

8. Run vehicle through a curve under power

   a) at 5 mph, 8 km/h
   b) at 10 mph, 16 km/h
   c) at 15 mph, 24 km/h

   Measure track deviations that cause severe motions.

9. Do test 7 for speeds up to 30 mph, 48 km/h.

10. Do test 5 for speeds up to 30 mph, 48 km/h.

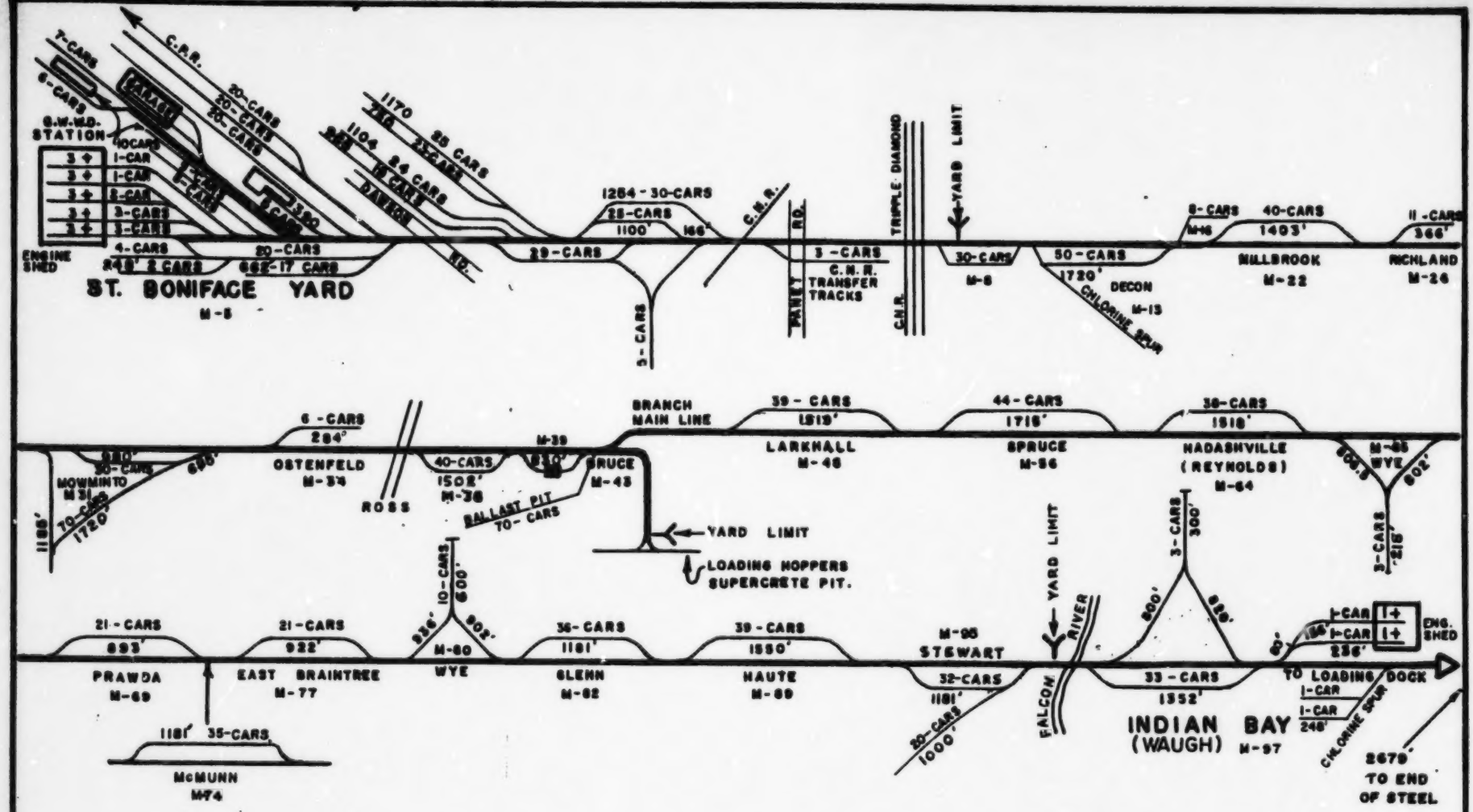
11. Do test 8 for speeds up to 30 mph, 48 km/h.

12. Do tests 7 and 2 for speeds up to 45 mph, 72 km/h or limiting condition.

13. Test runs across diamonds and switches at various speeds.

14. Report tests 7 and 8 at speeds up to 30 mph, 48 km/h.

TEST SITE



REVISED 16 MAY 1980 TM.
REVISED 14 FEB 1974 HB

NOTE:
CLEARANCE 180' ± FROM POINT OF SWITCH.
CAR LENGTH 40'

THE METROPOLITAN CORPORATION OF GREATER WINNIPEG
WATERWORKS & WASTE DISPOSAL DIVISIONS
DIRECTOR — A. PENMAN

CAR CAPACITY DIAGRAM

DES. _____ CHKD. _____
DRN. HB DATE 8 MAY 70
ENG. _____
APPROVED

SCALES
N. T. S.

DRAWING NO.
A-687

EQUIPMENT SPECIFICATION

The equipment used was a Western Flyer Bus with the following specifications:

BODY Bus type with full frame structure - for rail use only

MODEL Western Flyer T40161

WHEELBASE 244 inches (400 inches overall)

ENGINE Detroit Diesel 453 Cu. in. - 110 HP.

TRANSMISSION Allison (Automatic) Series AT540

DIFFERENTIAL Rockwell/Timken (2 wheel drive)

WHEELS 36" diameter railway wheels modified to fit bus hubs

WHEEL BEARINGS As normally used on the rear of tandem axle buses.
Inner Bearing Timken 681A
Outer Bearing Timken 580

BRAKES Bendix Westinghouse Air Brakes drum type at all four wheels w/7 inch brake blocks

PARKING BRAKE Hand Brake

FUEL STORAGE Tank 80 Imp. Gals.

LIGHTING Headlights, Market Lights, Signal Lights, Hazzard Warning Interior Lights

SEATING 38 Heavy Duty Vinyl Covered non-reclining Inter City Coach type seats with 15 3/4 inch spacing between seats

HEATING SYSTEM 7 Carter underseat heaters with 6000 B.T.U. per heater, total output 42000 B.T.U.

SPEEDOMETER Sigmanetics, Inc. electronic bus speedometer rated at 480 rev./mile based upon a normal bus wheel having a circumfrence of 132". (see table 1)

SHOCKS Bus heavy duty shocks mounted outside the main frame

WASHROOM Located at L.H.. rear of coach w/holding tank located below floor level and vented within wall panels to roof aperture.

BAGGAGE LUGGAGE AND/OR EXPRESS Five storage compartments. Total capacity approx. 170 cu. ft. Two interior overhead luggage racks, capacity approx. 66 sq. ft. of floor area.

PASSENGER ESCAPE DOOR 33 inches by 49 inches escape door (manually operated).

INSULATION Coach body insulated through with one inch rigid foam board (non-inflammable) insulation.

RADIO Two-way radio, included for contact with Thompson frequency.

REVERSING UNIT A built-in turntable located in the centre of the bus forming part of the chassis.

PASSENGER STEPS A fold down retractable step is to be provided to facilitate entrance to and exit from the railbus.

2. Video Equipment

Video tape recorder and monitor mounted to view the front, right side wheel/rail interface with brackets on the fixed axle and on the sprung frame. 120 V power supply from a portable gas generator mounted in the rear of the bus.

APPENDIX C

TEST PROGRAM PARTICIPANTS & OBSERVERS

Doug Smith	Transport Canada
Bert Luckhurst	Resource Development Associates (for Winnipeg Coach)
Dave Gardiner	TEAM Consultants (for Winnipeg Coach)
Roy Fatidoe	C.N. Rail
M. J. Babulic	Inco Ltd.
Sam Berrada	C.N. H.Q.
Brian Marshall	Transportation Development Centre
R. N. Blaikie	C.N. Rail
J.A. Stenhouse	C.N. Rail
Barry Myers	Transportation Development Centre
Orest Ochitwa	Winnipeg Coach
Jim Wallace	Manitoba Highways & Transportation
John Rae	Manitoba Highways & Transportation
J. Craven	Manitoba Highways & Transportation
Bill Zuk	Video Cameraman

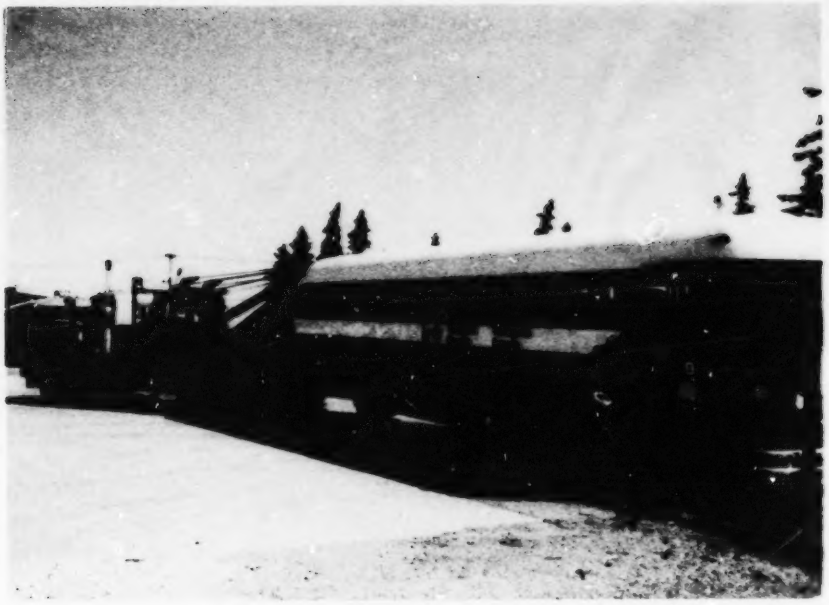


Photo. 1 - Placing Railbus rear wheels on rails at GWWD yard.

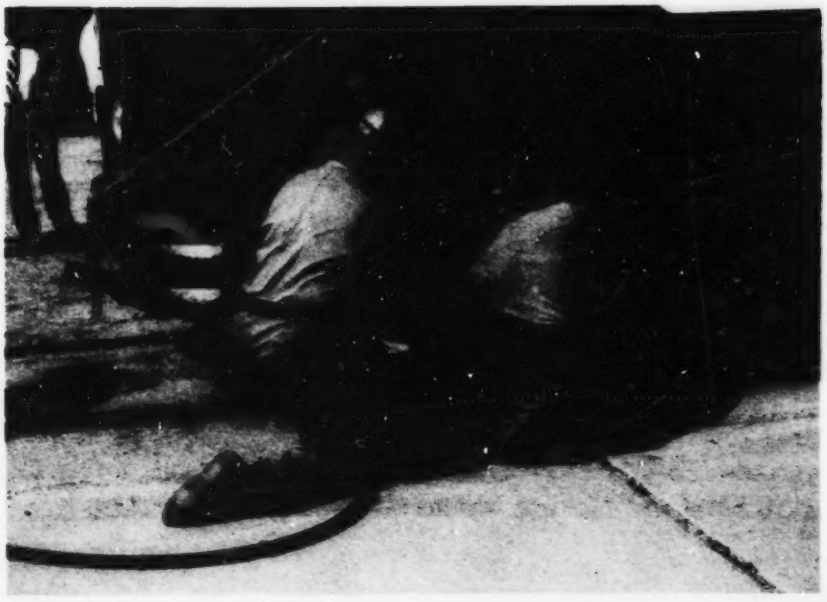


Photo. 2 - Removing rubber tires from front wheels.

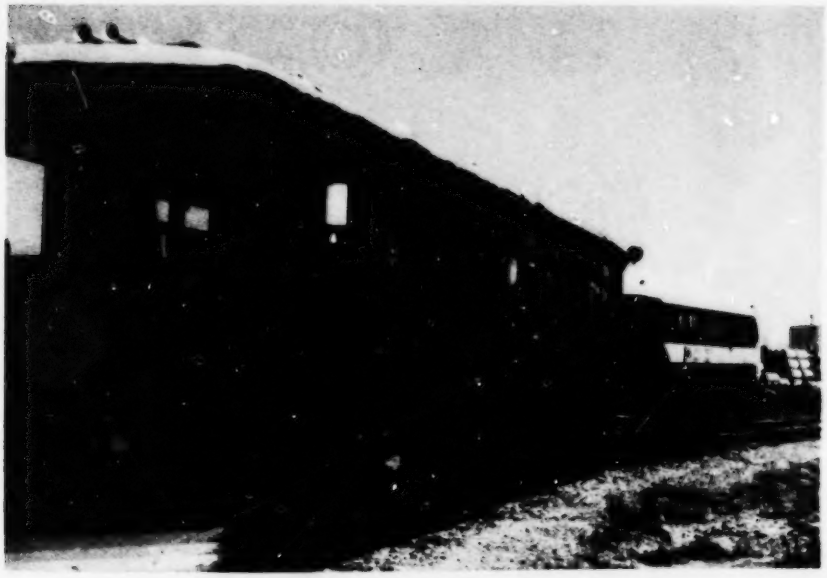


Photo. 3 - Initial Push/Pull testing on tangent track.

Photo. 4 - Push/Pull testing on curved track.

Photo. 5 - Powered Testing on tangent track.

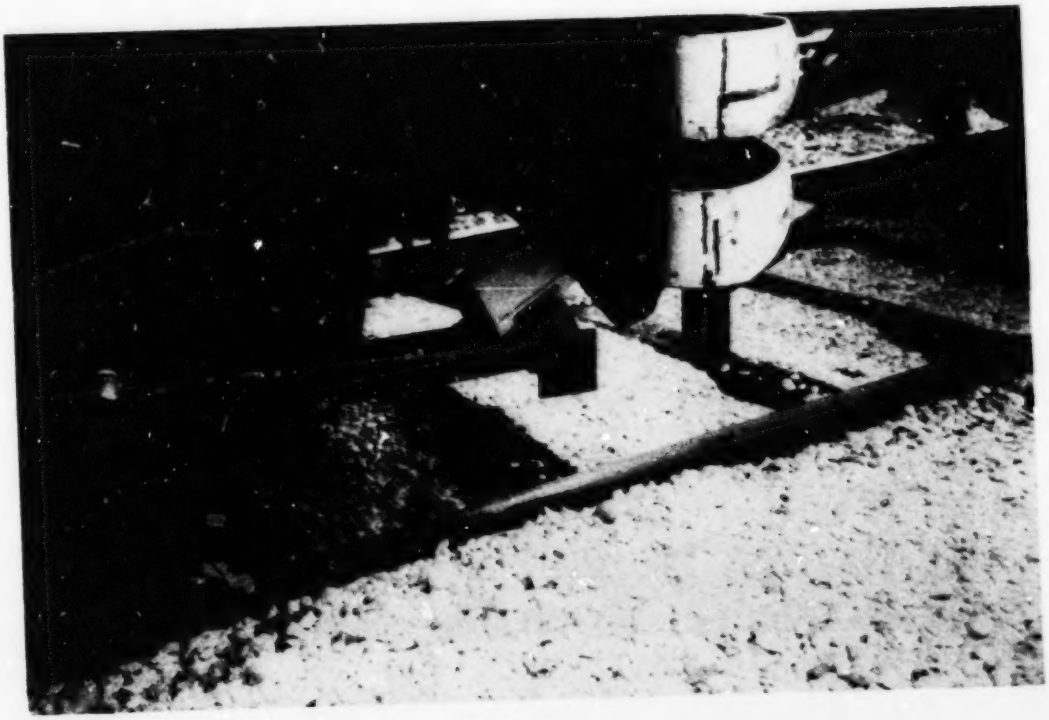
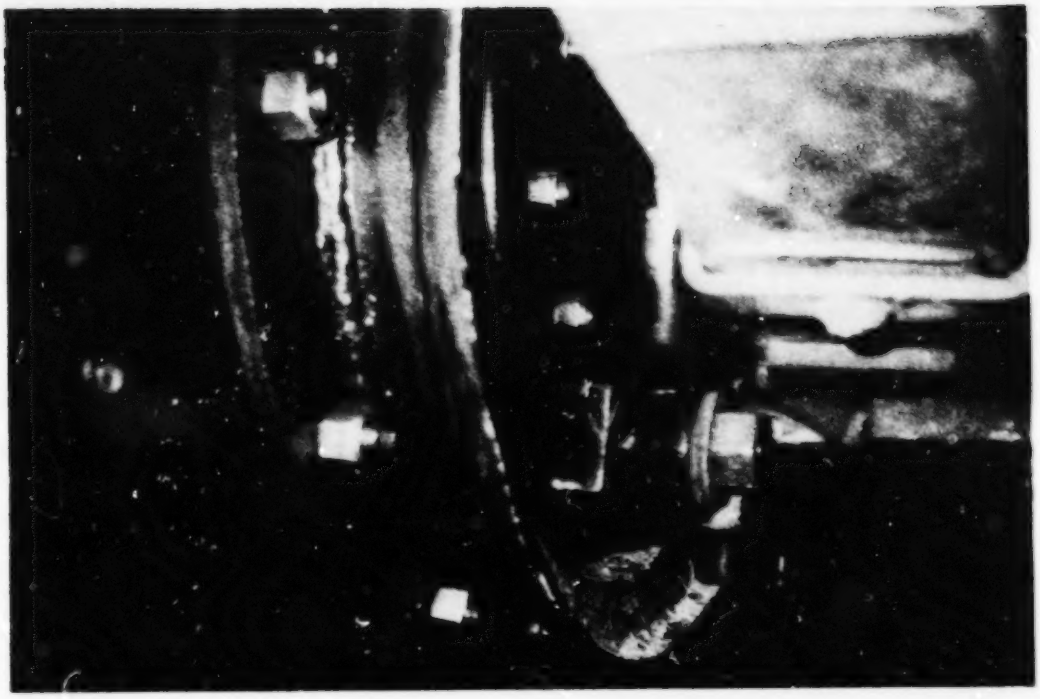


Photo. 6 - The video camera focused on the wheel and rail.



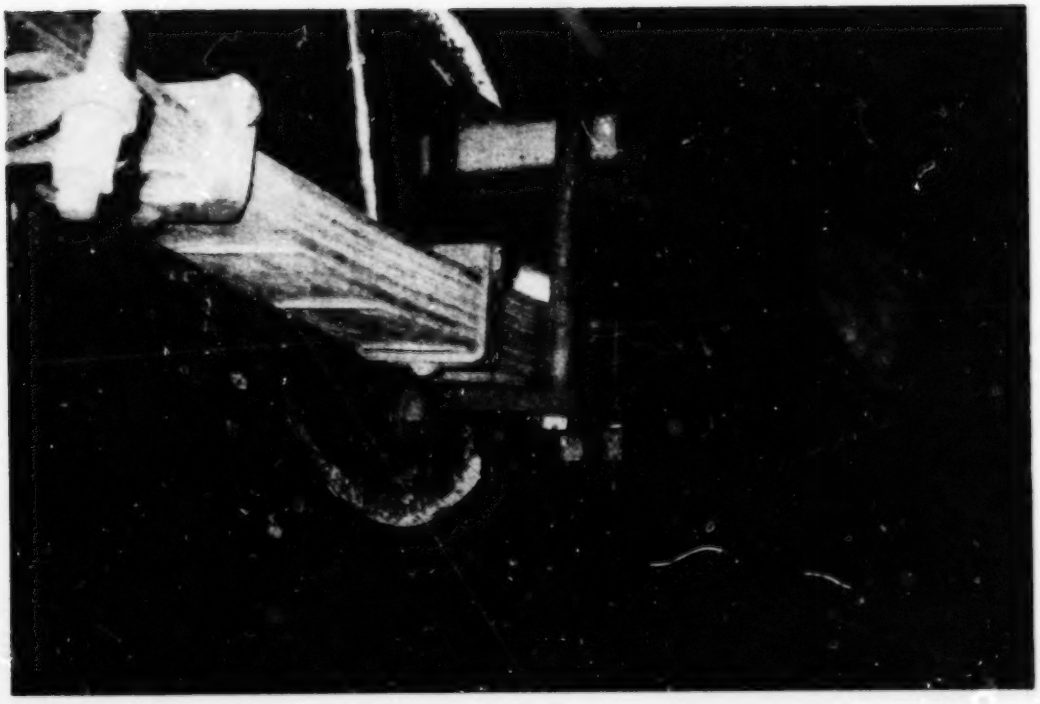


Photo. 7 & 8 - Showing construction of front under-carriage, axle springing and shocks.

Photo. 9 - Railbus at Mile 31, GWWD Line.

REVISED SPECIFICATIONS

Prior to Phase II the following changes were made to Bus Specifications given in Appendix B:

BRAKES	Brake pressure shall be adjustable so that wheel locking can be minimized.
LIGHTING	... installed to conform to Interstate Commerce Commission Regulations as well as Provincial and Federal Regulatory Bodies in Canada.
SEATING	Twenty-five (25) Heavy Duty Vinyl covered non-reclining Inter City Coach type seats with 15-3/4 inch spacing between seats.
HEATING SYSTEM	Carter underseat heater seven (7).
HEATER RATING	12 Volt 6,000 B.T.U. per heater. Total output 42,000 B.T.U.'s. Heating system being 100% re-circulated air through heaters. Fresh air available. Fan motors speeds of all heaters and windshield defrosters, controlled through variable speed type switches mounted on dash at driver's positions. Fresh air fan controlled through direct on/off switch. Ventilation and heating systems selected and controlled through master alternating switch.
WASHROOM	Lighting in washroom effected by control switch in door locking device.
BAGGAGE LUGGAGE AND/OR EXPRESS	Added interior storage shelves at rear of vehicle (Wire mesh type).
PASSENGER ESCAPE DOOR	... located to the rear of midway point of coach body on left hand side (opposite side to passenger entrance door).
RADIO	Auxilliary two way mobile radio telephone for contact with Manitoba Telephone System (25 W - VHF - 13 channel).
REVERSING UNIT	... and capable of being operated by one person. Indicators will guide the operator in ensuring safe lifting conditions exist.

VEHICLE PERFORMANCE	This vehicle as specified herein will conform to the initial requirement of maximum operating speed of 60 km per hour with an ultimate maximum speed of 75 km per hour.
NOISE	Engine and transmission shall be insulated from the passenger area such that a noise level at 85 dbA is not exceeded at maximum cruising speed.
RAIL WHEELS	REAR A matched pair of 36" diameter rail wheels mounted on road wheel drums will be installed. A second complete spare set shall be provided. FRONT A matched pair of 36" diameter rail wheels will be installed, mounted on road wheel drums. A second complete spare set shall be provided. All wheels shall be coded for matching.
ROAD WHEELS	A full set of four (4) wheels with tires mounted shall be provided.

SNOW/PLOW COW CATCHER

POWER WINCH (Braden AMU7)

AUXILLIARY HEATER (Espar D4L - 15,000 B.T.U.)

DOUBLE WINDOWS & HEAVY DUTY SCREENS (Storm-Tite)

RE-INFORCED WHEEL WELLS

SECOND AMENDED SPECIFICATIONS

On April 15, 1985 there were further changes in the work specifications which added the following:

"STATEMENT OF WORK"

1. Remove springs and re-arch to raise plow as required by railroad standards.
2. Provide and install thermostat control for heating system.
3. Provide and install viewing window over wheel wells.
4. Supply three (3) spare windows c/w frames.
5. Provide and install engine block heater.
6. Provide and install dampers for spring shackles, restraining rods and spring plates.
7. Replace rear shock absorbers.
8. Provide and install guards for heaters and hoses at floor.
9. Supply and install Sonalert for reverse.
10. Supply and install backup lights.
11. Provide and install winter radiator protector.
12. Provide and install drive shaft safety support.
13. Supply spare passenger seat cushion and lazy back.
14. Supply first aid kit.
15. Supply and install fire extinguisher, 2.3 kilo, 195 psi ULC #F311479C.
16. At the end of Phase II testing, mark and identify wheels, check alignment, examine welds for cracks, remove and inspect bearings, check gauges, check fuel consumption.
17. Undertake Phase III of railbus testing for two (2) days of equipment checks and running trials on GWWD tracks in Winnipeg. The work includes planning and preparation, providing driver and trainman, testing

program co-ordination, supervision, engineering and mechanical services, bus delivery to site and return, fuel, crewing, track leasing charges and any other required expenses. Liability insurance shall be acquired as specified under the "Insurance" provisions of Amendment #1.

APPENDIX G

TURNTABLE COMPONENTS

The following are the principal components for the turntable and the manufacturers of each part:

Turntable Bearing	Kaydon K7 25E12
Turntable Pinion	3½ in. diameter X 2 in. face
Turntable Drive Motor	Charlyne 104-1228
Turntable Cylinders (4)	4 in. diameter bore 15 in. stroke 1 3/8 in. shaft
Power Take-off	Chelsea Model 379135
Oil Pump	Vickers V.20 capacity - 12 gals/min.
Selector Valves	(3) Gresen - 3 position levers
Flow Dividers	(4) Gresen - PD 50 - 50
Flow Controls	(3) Gresen - F.800-S
Hoses	1/2 in. FJ X 1/2 in. MP

Winch

Motor	Charlyne 104-1228

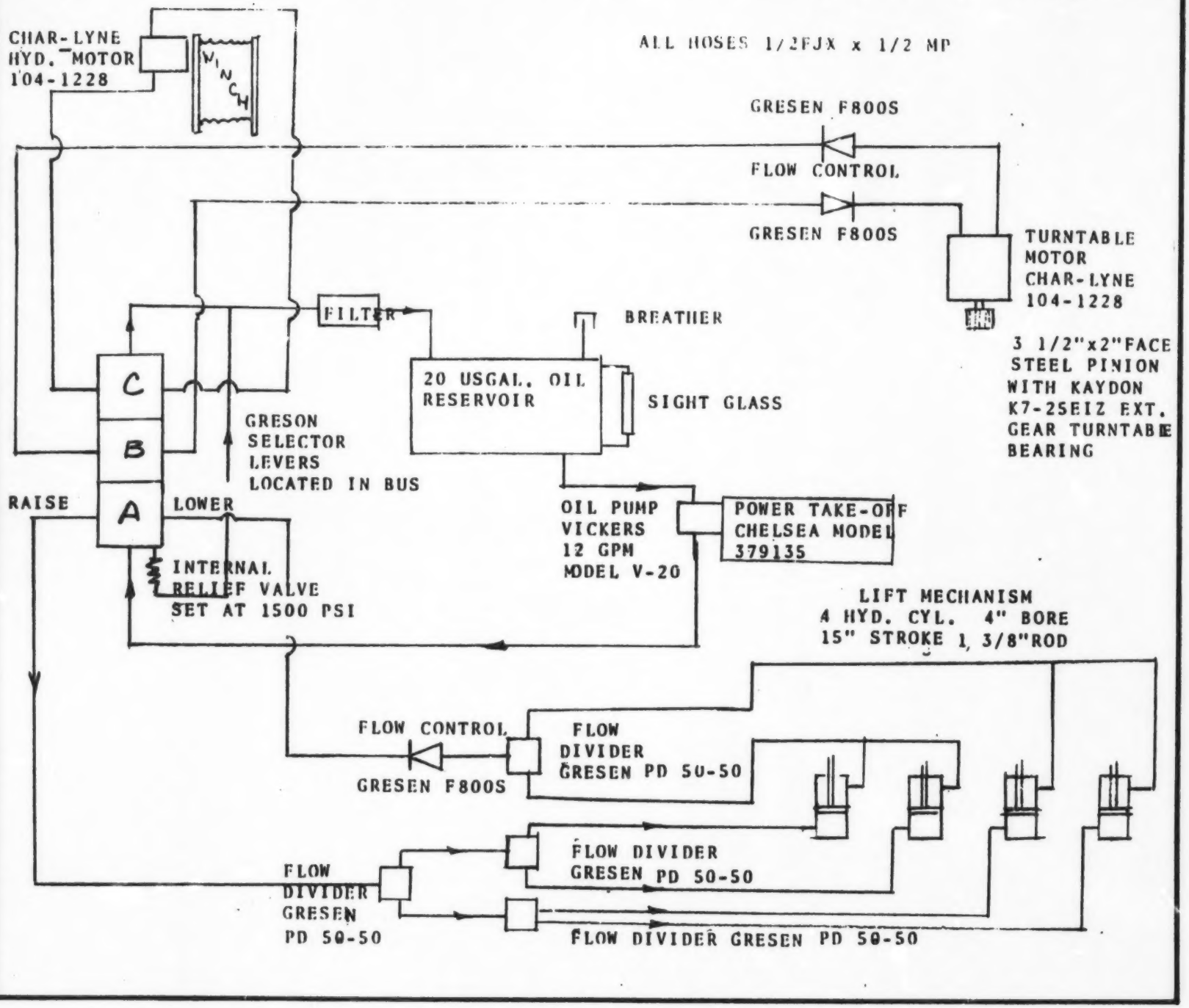
TURNTABLE OPERATING PROCEDURE

1. Put vehicle in "DRIVE" gear with foot brake applied.
2. Engage power take-off by pulling up PTO knob located on dashboard.
3. Wait until two (2) red lights appear. Engaging the power take-off automatically releases the LIFT TABLE SAFETY LOCK. The red lights indicate that the PTO is fully engaged and the safety lock is free.
4. Put vehicle gear shift in "NEUTRAL".
5. Release foot brake.
6. To RAISE the bus (lower the lift table) lift lever "A" located to the right of the engine compartment on the dashboard. Hold until no further movement is felt or the operator hears the oil pump labouring.
7. Release the lever and it will return to a neutral position.
8. To rotate bus to the left push down on lever "B".
   To rotate bus to the right lift up on lever "B".
9. Note that the speed of rotation is fixed by the speed of the engine and the idle speed is normally adequate unless a heavy wind occurs. Final positioning can be accomplished by manipulating the lever.
10. Line up track with indicator on front of plow and release lever. It will return to a neutral position and the rotation will stop.
11. To lower bus push down on lever "A" until green light appears on dashboard. Step out on ground to ensure vehicle is on tracks.
12. Release PTO by pushing down PTO knob. This automatically disengages the system and applies the TABLE SAFETY LOCK. The red lights will both go off to indicate the vehicle is ready to be driven.
13. Engage "DRIVE" gear and drive normally.

TURNTABLE HYDRAULIC SCHEMATIC DRAWING APPENDIX I

DATE AUG 11/85 | DRAWN DMG | SCALE NTS | DWG L 1 of 1 | FILE WPG COACH | PROJECT BUS

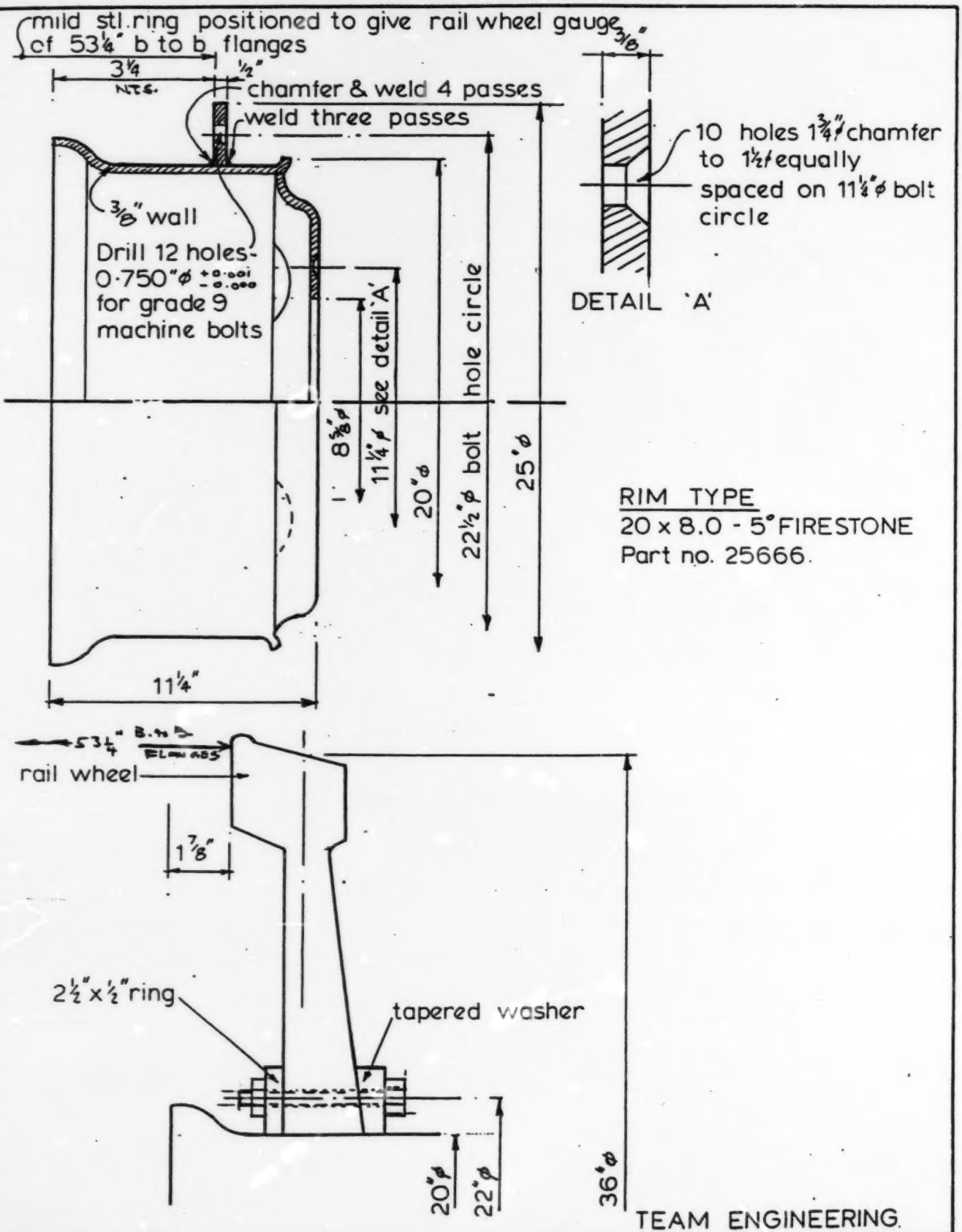
TEAM Consultants - Winnipeg
RAIL BUS MARK I
HYDRAULIC SCHEMATIC



WINCH OPERATING PROCEDURE

The winch that was installed requires the following operating procedure:

1. When winch is used follow steps 1 to 5 of "Turntable" procedure.
2. Manually engage winch drum above the plow outside at the front.
3. To operate use lever "C". Pull "UP" to extend cable (someone must pull it on the outside) and push "DOWN" to retract it.
4. When completed rewind winch and disengage it outside.
5. Repeat step 13 to release PTO.
6. Put vehicle in gear and drive normally.



APPENDIX K

RAIL BUS HUB DETAILS

DATE nov 85

REF.

NO.